Engineers Australia
Engineering Heritage Victoria

Nomination

Engineering Heritage Australia, Heritage Recognition Program

for the

FYANSFORD BRIDGE,

GEELONG, VICTORIA

A Pioneer of the Monier Concrete Arch Construction Method

July 2012

Front Cover Photograph Caption

Fyansford Bridge in 2007 taken from the upstream side on the eastern bank of the Moorabool River. The ends of cross-ties can be seen in the spandrel walls near the centre of each arch. No other signs of change to the original bridge as-built are visible.

Image: Marcus Wong Wongm

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1 Introduction

Engineering Heritage Victoria has been looking for opportunities to recognise heritage sites related to the work of General Sir John Monash in the build-up to the centenary of the Landings at Anzac Cove in April 2015. In 2011 we recognised the Janevale Bridge, a reinforced concrete pier and T beam bridge near Bendigo and the Yallourn Power Station.

Engineers Australia, Victoria Division are holding a Country Weekend on 12-14 October 2012 as a part of the national Year of the Regional Engineering Team celebrations. The event will be held in Geelong and it was thought that the opportunity to include a heritage recognition ceremony in the event should be considered.

The coincidence of these two objectives clearly pointed to the heritage recognition of the Fyansford Bridge which is about 4 km west of Geelong on the Geelong to Hamilton Highway.

As the first Monier arch bridge to enter service in Victoria,[1] built by Monash and Anderson and spanning the turn of the twentieth century this significant bridge is a welcome addition to the list of sites recognised under the national Heritage Recognition Program and also furthers several key objectives of Engineering Heritage Victoria.

The old Fyansford Monier Arch Bridge serves as a pedestrian and bicycle bridge for the B140 Hamilton Highway now running across the Moorabool River on a new (1970) reinforced concrete T beam bridge immediately to the south.
Image: Google Earth.

[1] Some authors claim that Anderson Street was the first to come into service. Whilst Anderson Street Bridge was tested in July 1899 it did not carry traffic immediately as the approach roads had not been completed (refer to Alan Holgate dossier on Anderson Street Bridge). Meanwhile Fyansford Bridge carried traffic unofficially in December 1899 and was tested on 16 February 1900.

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2 Heritage Award Nomination Letter

The Administrator
Engineering Heritage Australia
Engineers Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Name of work: Fyansford Bridge, Fyansford, near Geelong, Victoria.

The above-mentioned work is nominated for an award under the National Heritage Recognition Program.

Location, including address and map grid reference if a fixed work: Bridge crosses the Moorabool River and previously carried the B140, Hamilton Highway. Grid references:

38°08'3-.96' S
144°18'31.36" E
Elevation: 36 feet (11 m)

Owner (name & address): VicRoads, Geelong Office, 180 Fyans Street, South Geelong Vic 3220.

The owner has been advised of this nomination and a letter of agreement is attached.

Access to site: The bridge is fully accessible and serves as a public footpath.

Nominating Body: Engineering Heritage Victoria.

Miles Pierce
Chair, Engineering Heritage Victoria

Date: 20 August 2012

3 Heritage Assessment

3.1 Item Name: Fyansford Bridge

3.2 Other/Former Names: Old Fyansford Bridge; Fyansford Monier Concrete Arch Bridge

3.3 Location: Crossing the Moorabool River, 4 km west of Geelong city centre adjacent to the B140, Hamilton Highway

3.4 Address: As above

3.5 Suburb/Nearest Town: Fyansford

3.6 State: Victoria

3.7 Local Govt. Area: City of Greater Geelong

3.8 Owner: VicRoads

3.9 Current Use: Road bridge no longer in use now pedestrian bridge

3.10 Former Use: Road bridge (including pedestrian and bicycle use)

3.11 Designer: Monash and Anderson, Melbourne

3.12 Maker/Builder: Monash and Anderson, Melbourne

3.13 Year Started: 1899

3.14 Year Completed: 1900

3.15 Physical Description: Monier arch bridge consisting of 3 spans (1 x 100 feet for the river crossing, 2 either end of 60 feet).[2] Width between kerbs 20 feet.[3]

3.16 Physical Condition: In "fair" condition[4]

3.17 Modifications and Dates: In December 1905 there was concern over the state of the spandrel walls which seem to have shifted outwards due to pressure of the fill. They were strengthened by the insertion of cross-ties.[5] Substantial repairs were carried out in 1970-

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[2] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982, page 3.

[3] Ibid, page 5.

[4] RBA Architects and Conservation Consultants Pty Ltd, Conservation Management Plan, August 2009, page iii.

[5] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982, page 12.

1989 but these were primarily for the correction of defects in the bridge which had developed over time rather than modifications.[6]

3.18 Historical Notes:

The area around Fyansford was settled by Europeans relatively early as it offered a good water supply and land that was suitable for grazing and growing crops. Its location at the junction of the Moorabool and Barwon Rivers, with reliable rainfall, supported several industries including the production of paper, timber, flour, and cement.

Fyansford is located on the Hamilton Highway on the western outskirts of Geelong. Fyansford - Fyan's Ford - is named after Captain Foster Fyans, the first Police Magistrate for Geelong and district. When Fyans took up his post in 1837, he settled on land near the crossing point, or ford, over the Moorabool River that later formed the common border between the Shires of Corio and Bannockburn. As Magistrate, Fyans' role included Protector of Aborigines and he undertook to take a census of the Aboriginal population, calling upon Buckley[7] to gather the Wathaurong people and count them. In 1840, he was also Commissioner of Crown Lands for the western area of the Port Phillip District, a position from which he played a significant role in local government and in the development and planning of early settlement in Geelong and surrounding areas.

Before his death in 1870, he had served as a Councillor and Mayor of the City of Geelong and as Deputy Sheriff.[8]

The Fyansford Bridge was built at the turn of the twentieth century, and at a time when bridge construction was undergoing a major change. Technology in Australia 1788-1988 [9] says:

> "With the start of the twentieth century, however, three important factors came to bear on Australian bridge design - the advent of concrete and steel, and the emergence of scientific design".

One system which flourished to utilise concrete in structures was the Monier system:

> "The Monier system of construction was patented in 1867 by Joseph Monier, a French manufacturer of garden ware. He manufactured planter pots made of coarse mortar reinforced with a grid of small-diameter iron bars. The technique and patents were gradually extended to cover, amongst other things, arch bridges. The technique was forcefully developed and promoted in the German-speaking world by a number of licensees, amongst whom G A Wayss became dominant. It was formally introduced to Australia in the early 1890s by W J Baltzer, a German immigrant

[6] RBA Architects and Conservation Consultants Pty Ltd, Conservation Management Plan, August 2009, page 15.

[7] William Buckley was a white man and escaped convict who had been living with the Aborigines for many years. Refer Wikipedia on William Buckley.

[8] RBA Architects and Conservation Consultants Pty Ltd, Conservation Management Plan, August 2009, page 5.

[9] Australian Academy of Technological Sciences and Engineering, Technology in Australia 1788-1988, 1988.

> working for the NSW Public Works Department, who joined several businessmen to obtain licenses through Wayss to cover the Australian Colonies. The firm of Carter Gummow & Co was formed and built two important arched sewage aqueducts in Sydney and a number of smaller structures. Baltzer moved across to become effectively its Chief Design Engineer".[10]

Monash and Anderson, in Melbourne, took up the Monier system and built a number of arch bridges using the system under an arrangement with Carter Gummow & Co in Sydney.

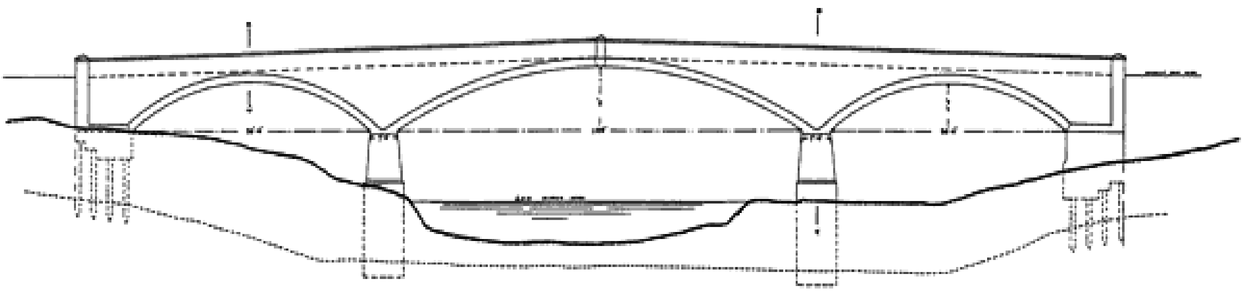
The Anderson Street bridge over the Yarra River (also known as the Morell Bridge) and the Fyansford Bridge were the first two projects using the Monier arch in Victoria.

The proposed bridge at Fyansford was to replace a deteriorated wooden bridge and was the joint responsibility of the Corio and Bannockburn shires as their boundary was the Moorabool River.

The Fyansford bridge project was initiated largely by JTN Anderson while John Monash was preoccupied with legal cases. [11]

> "By 5 October 1897 Anderson had investigated site conditions at Fyansford and sent Gummow a preliminary sketch.... Carter Gummow responded with a drawing showing three arches, each with a 90-foot (27.4m) clear span".[12]

Negotiations between Anderson and the two councils commenced. The councils formed a Joint Committee to oversee the awarding of a contract. The councils decided that they would not call tenders. Several different bridge arrangements were considered and many variations in the details of construction were discussed.



Fyansford Bridge as finally agreed with one 100 foot river span and two 60 foot side spans.
Image: Alan Holgate paper on Fyansford Bridge.

The work of Alan Holgate goes into detail about these negotiations at pages 3-5 of his paper.[13] A great deal of the discussion revolved around the cost of the project. With

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[10] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982, page 2.

[11] Ibid, page 1,2.
[12] Ibid, page 3.

hindsight we can see that the councils were attempting to manoeuvre Monash & Anderson into a situation which would later prove financially disastrous for Monash & Anderson. The behaviour of the councils was later described by one of the judges involved as ”entrapment”. It could also be said that Monash & Anderson were not sufficiently careful in establishing that a correct written record of the contract was in their possession.

In February 1899 work commenced and despite tactics of delay, obstruction and obfuscation by the councils the downstream arches were successfully cast on 14, 15 and 16 August [14] and the upstream arches on 11, 25 and 26 October [15] 1899. The bridge was tested on 16 February 1900. [16]

The work of Alan Holgate goes into detail about the construction period at pages 5-8 of his paper.[17]

The work was satisfactorily completed in less than one year, despite the efforts of the councils to delay it, but the councils were not prepared to pay for much of the work. Legal action commenced on 17 June 1901 to force the final claim for payment and the judgment was in favour of Monash & Anderson. Despite this result the councils still did not pay and in December 1901 Monash & Anderson had the Sheriffs seize the contents of the two town halls although this netted only a small sum for Monash & Anderson. The matter then went to appeal which overturned the original decision in favour of Monash & Anderson. Monash & Anderson did not have the financial resources to take the matter to the next court of appeal which was the Privy Council. [18]

Monash & Anderson made a loss of approximately £3000 on the project including losses on the actual construction and the cost of the ultimately unsuccessful legal case against the councils.[19]

The work of Alan Holgate goes into detail about the legal battle at pages 9-12 of his paper. [20]

In 1970 a new road bridge was built on the site of the old wooden bridge to carry heavier traffic on the Hamilton Highway, the 1900 bridge was retained for pedestrians.[21]

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[13] Ibid.

[14] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982, page 7.

[15] Ibid, page 8.

[16] Ibid, page 9.

[17] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982.

[18] Ibid, pages 9-12.

[19] RBA Architects and Conservation Consultants Pty Ltd, Conservation Management Plan, Aug 2009, page 14.

[20] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982.

[21] Wikipedia, Moorabool River, version last updated on 25 October 2011, downloaded 6 July 2012.

3.19 Heritage Listings

3.19.1 Heritage Victoria

Name: Old Fyansford Bridge (Bridge over Moorabool River 1900) 2005 Hamilton Highway, Fyansford
Level of Significance: Registered
Victoria Heritage Register (VHR) Number: H1108
Date Listed: Not known
Note: The area covered by this registration is the plan area of the bridge plus 3 metres all around.

3.19.2 National Trust of Australia (Victoria)

Name: Fyansford Bridge, Hamilton Highway over Moorabool River, Fyansford
Level: State
Register Number: B2841
Date Classified: 5 August 1971

3.19.3 City of Greater Geelong Heritage Overlay

Name: Old Fyansford Bridge (Bridge over Moorabool River 1900) Hamilton Highway, Fyansford
Level: Registered
Heritage Overlay Number: B088
Date Classified: Not known

Refer to Appendix 2 for more details of this listing.

3.19.4 Australian Heritage Council - Register of the National Estate

Name: Moorabool River Bridge, Hamilton Highway, Fyansford
Level: Registered
Place ID: 16058
Date Classified: Not known

4 Assessment of Significance

4.1 Historical significance:

See section 3.17 above for details of the history of this site.

The particular significance of this site lies in its place in the evolution of bridge building materials and methods. It was the first Monier arch bridge built and placed into service in Victoria. Whilst the similar Anderson Street Bridge in Melbourne (later called the Morell Bridge) was completed before Fyansford it came into service later than Fyansford due to delay in the completion of approach roadworks.

Following the construction of 19 Monier arch bridges[22] by Monash and Anderson in Victoria the style of bridge changed to reinforced concrete girder bridges from about 1910 onwards. This technique remained the most popular type of construction of road bridges until the present day with some refinements such as the prefabrication of bridge beams.

Hence the Fyansford Bridge can be said to stand at the change from predominantly masonry or timber bridges to reinforced concrete road bridges in Victoria.

Furthermore the design of Carter Gummow and Co and Monash & Anderson have stood the test of time. Many are still in service more than a century after they were built and whilst there was evolutionary change in the design of reinforced concrete structures we can now see the early Monash and Anderson bridges as providing a very firm basis on which bridge design and construction in the 20th century was based.

4.2 Historic Individuals or Association:

See Appendix 3 for biographical information on:

1. John (later General Sir John) Monash
2. Joshua T N Anderson
3. Joseph Monier
4. Alan Holgate

4.3 Creative or Technical Achievement:

The Monier bridges built in Victoria were based on the Monier patents which came to Australia via W J Baltzer and a licence in the Australian Colonies was taken out by Carter Gummow & Co in Sydney. Monash & Anderson worked quite closely in association with Carter Gummow & Co in Sydney although there were disagreements between the two companies over design details on occasions.

Monash & Anderson carried out detailed design and construction supervision with considerable precision and there were apparently remarkably few problems with the early bridges built. For instance the main arches of the downstream half of the Fyansford Bridge were cast on successive days in 1899.

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[22] Alan Holgate, list of Arch Bridges. Note that one of the bridges was built much later , in 1913, after the Monash & Anderson partnership had been dissolved.

The bridges were not highly decorated by the standards of their time and it is clear from discussions between the councils and Monash & Anderson at Fyansford that additional decoration added to cost which was not attractive to the councils who were “stretched” for funds to build the bridge.

The technical achievement can therefore be seen as primarily a systematic approach to the application of the patent design in a workman-like manner, constructed in relatively short timeframes in order to provide councils facing the need to expand and improve their road networks at the lowest possible cost.

It should also be noted that the Monier arch bridges were not strictly speaking ‘reinforced concrete’ in the modern sense. They were designed specifically so that the arches carried only compressive load[23] in such a way that the reinforcing served only an ancillary function of dealing with minor un-predicted localised tensile stresses in the arch. In other words the bridges could have been constructed without reinforcing.

4.4 Research Potential:

Considerable work has been done by researchers such as P F B Alsop and Alan Holgate on the work of Monash and Anderson. No particular areas for further research appear to be pressing however as new material comes to light further research will undoubtedly occur. For instance in the week when these words were written intelligence came to light suggesting that a cabinet full of Monash & Anderson drawings, not previously known of, and not currently in the public arena have been found. Careful scrutiny of these drawings may throw more light on the designs, methods and contractual issues relating to the work of the partnership.

4.5 Social:

The early 20th century saw a very rapid expansion of the road network in Victoria. This expansion led to the construction of very large numbers of bridges. When the Country Roads Board was formed in 1913 [24] it quickly started to standardise bridge design to allow the more rapid expansion of the road network.

The work of expanding the road network was fundamental to the social changes relating to the adoption of the motor car which started at the turn of the 20th century and accelerated rapidly after the Second World War. This was one of the most profound social changes of the 20th century, leading most families to own at least one car by the 1960s.

The bridges of the Victorian road network, most of them quite modest in size, were critical to the achievement of this social change. The key issue for this story is that most of these bridges were built of reinforced concrete which proved to be cheap, durable and resistant to fire damage. The Monash & Anderson Monier bridges mark the beginning of concrete bridges in Victoria and for this reason they should be recognised and preserved.

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[23] Refer Appendix 8/.

[24] Refer to VicRoads Web site. History of the CRB.

4.6 Rarity:

Monash & Anderson built 19 Monier arch bridges in Victoria between 1899 and 1913. 11 of these bridges survive, at least 4 have been demolished and a further 4 are uncertain.[25] It cannot therefore be said that these bridges are rare.

More importantly we need to work to ensure that the remaining bridges are maintained, preserved and protected.

4.7 Representativeness:

The Fyansford Bridge is representative of the Monier Arch Bridges built by Monash and Anderson. It is, however the oldest example (if judged by its date of coming into service) and is one of the larger of the remaining bridges.

4.8 Integrity/Intactness:

The bridge appears virtually as first constructed. The only visible change is the addition of some cross-tie rods at the crown of each arch. [26]

It is known that this design of bridge tended to suffer bulging of the spandrel walls. In December 1905 there was concern over the state of the spandrel walls which seem to have shifted outwards due to pressure of the fill. They were strengthened by the insertion of cross-ties. [27]

Monash & Anderson undertook the repairs.

[25] Statement based on evidence from the Alan Holgate web site. All information was taken from the papers referenced in the table of Monier arch bridges. The bridges demolished are the First King Street Bendigo bridge [This was the bridge which failed under test]; Myrtle Street and Oak Street Bendigo and Ford Creek at Mansfield, demolished in 1972. The status of the following bridges is not stated in the material: Barbers Creek, Whittlesea; Wollert , Whittlesea; Scott Creek Culvert Moorabool and the Coliban Reservoir Spillway Bridge.

[26] Alan Holgate Vicnet web site. Table of Monier Arch Bridges built in Victoria

[27] Holgate, Alan, John Monash Engineering enterprise prior to WW1, Fyansford Monier Arch Bridge, Dossier, with acknowledged reliance on Alsop, 1982, page 12.

5 Statement of Significance:

5.1 National Trust of Australia (Victoria) [28]

The Fyansford Bridge, erected in 1899 and opened for traffic in February 1900, is the first bridge in Victoria completed using the new reinforced concrete technique developed in Europe and known as the 'Monier' principle Sydney engineers Gummow and Carter introduced the system to Australia and leading Victorian engineers John Monash and J.T.N. Anderson pioneered this work in Victoria. The Fyansford Bridge is or (sic) paramount importance to this history of technology in Australia which finely defined proportions over the three spans of arches contributing to its notable aesthetic qualities.

5.2 Register of the National Estate (now downgraded to a non-statutory archive) [29]

This bridge was completed in 1899 and has three concrete arch spans of 18.3m, 30.5m and 18.3m. It is the fifth oldest of recorded existing Australian concrete bridges, after Lamington, Queensland (1896), the White's Creek and Johnstone's Creek aqueducts (both 1896), the Morell Bridge in Melbourne (1899) and Myrtle Street Bridge in Bendigo (also 1899). It is also large. The main span of 30.5m is the same as the previous largest span, in the Morell Bridge, and was not exceeded until the 1924 Church Street Bridge in Melbourne (32.3m). Accordingly it was a large example of a concrete arch bridge for its time. The designers were Monash & Anderson, of whom Sir John Monash is famous also for his army career.

5.3 Conservation Management Plan [30]

The following proposed statement of significance conforms with the format currently adopted by Heritage Victoria.

What is Significant?

The township of Fyansford was developed from the early 1840s and with the onset of the gold rush, traffic between Geelong and central Victoria increased rapidly. The first bridge across the Moorabool River at the site, a timber structure, was opened in 1854 however by 1867 was in need of regular repair. In 1897, it was described as being in a precarious condition so that the Bannockburn and Corio Shires, on whose border it was located, agreed to replace it.

Only a few structures had been constructed with reinforced concrete at this stage in Australia, mostly in NSW, and so the Monier system was perceived by some of the

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[28] Extracted from the National Trust of Australia (Victoria) web page on 8 July 2012.

[29] Extracted from the search engine of the Commonwealth Government Australian Heritage Database on 8 July 2012.

[30]

Councillors as an experimental technology. As such, it took considerable persuasion on the part of J T N Anderson of Monash & Anderson to bring them round to this option. For much of the gestation period of the project (late 1897 to early 1899), and some of its construction, John Monash was interstate. Cost however won out in the end as the reinforced concrete option was substantially less expensive than a timber and steel alternative.

Although Anderson was largely responsible for the overall design of the structure, Walter Baltzer who had brought the Monier system to Australia in the early 1890s, undertook most of the computations for the reinforced component, which is limited to the lower band of the three spans. Baltzer at this stage was being retained by Carter, Gummow & Co, a Sydney-based firm, who procured the rights to the Monier patent in Australia. Local materials were used in the construction: cement from the Australian Portland Cement Company at Fyansford and basalt from one of the local quarries.

Excavation commenced on the foundations in February 1899, and by late April the piers had been brought to ground level. Subsequently work on the abutments began. Construction of the superstructure started in mid- August with the casting of the downstream, or northern, half of the three spans and then the northern spandrel walls. There were ongoing contractual dilemmas and the casting of the southern half of the spans was delayed until October. Subsequently it was possible to build the southern spandrel walls, introduce the fill, build the parapet walls, and lay the macadamised road. The rendering, mostly rough cast, was undertaken during December about the time that traffic was being intermittently allowed across the bridge. The bridge was finally load tested on 16 February 1900.

The Old Fyansford Bridge was the second Monier arch bridge to be constructed in Victoria, being opened some six months after the Morrell (Anderson Street) Bridge, which was designed by Carter, Gummow & Co though partly supervised by Monash & Anderson. Whereas the Morrell Bridge has three essentially equal spans of about

29 metres, the Fyansford Bridge has a central span of 30.5 metres and narrower flanking spans of 18.3 metres. The spans are segmental arches, whose band of reinforced concrete tapers towards the crown, and the impression of formwork has been retained on the intrados whereas the mass concrete walls (both spandrel and parapet) are finished with a combination of mostly roughcast render with smooth render to the projecting elements (pilasters, string courses, and coping). The deck is wider at either end and currently has a bituminous surface.

A protracted legal battle ensued over final payments, which initially favoured Monash & Anderson, but an appeal by the Bannockburn and Corio Shires before a full bench of the Supreme Court was largely to the advantage of the Councils. Steps towards an appeal to the Privy Council in London were taken by Monash & Anderson but were withdrawn so that they lost about £3000 altogether on the project.

The bridge is largely intact and stable however within a few years, an outward bulging of the walls became apparent and, although metal tie rods were introduced in 1906, the problem has persisted. By the mid-1960s, the width of the deck was insufficient to accommodate the amount of vehicular traffic so that a great risk was posed to pedestrians. A temporary footbridge was erected to the north at a lower level whilst the wider, third bridge at Fyansford was constructed to the south during the late 1960s. By the mid-1980s, repairs were required to the Old Fyansford Bridge though it was found to be structurally sound.

How is it Significant?

The Old Fyansford Bridge is of historical, technical and aesthetic significance to the State of Victoria.

Why is it Significant?

The Old Fyansford Bridge is historically significant as it has associations with a principal development phase of Fyansford about the turn of the 20th century, when the town was a relatively prominent industrial centre. Materials used in the bridge were produced locally.

The bridge is also historically significant for its associations with the engineers Monash & Anderson as well as Carter, Gummow & Co, and the original holder of the Monier patent in Australia, W J Baltzer. It is the largest Monier arch bridge mostly designed in Victoria.

The bridge is technically significant because it is an early example of the use of reinforced concrete in Victoria and the only substantial bridge using the Monier arch system with a much wider central span than flanking spans.

The Old Fyansford Bridge is aesthetically significant as a well-proportioned bridge, which is relatively simple in its detailing (by comparison with the contemporary Morrell Bridge), albeit with some classical undertones. Its relatively unaltered setting since the time of its construction contributes to the ability to interpret its significance.

6 Level of Significance:

State

7 Interpretation Plan

7.1 Interpretation Strategy

The strategy for interpretation of the Engineering Heritage Works is laid out in the latest version of EHA's "Guide to the Engineering Heritage Recognition Program". The interpretation will be by marking the works with an appropriate level of heritage marker; a public ceremony to unveil that marker; and an interpretation panel which summarises the heritage and significant features of the works for the public.

This plan provides a summary of the proposals for design, content, location, manufacture and funding of the proposed interpretation.

7.2 Date for the Event

The ceremony should be held on **Friday 12 October 2012** at 3:00pm. (to be confirmed) This coincides with the running of the Victoria Division Country Weekend in Geelong hence providing a boost to Engineers Australia member's attendance at the event.

7.3 The Interpretation Panel:

The following will be incorporated into the design of the panel:

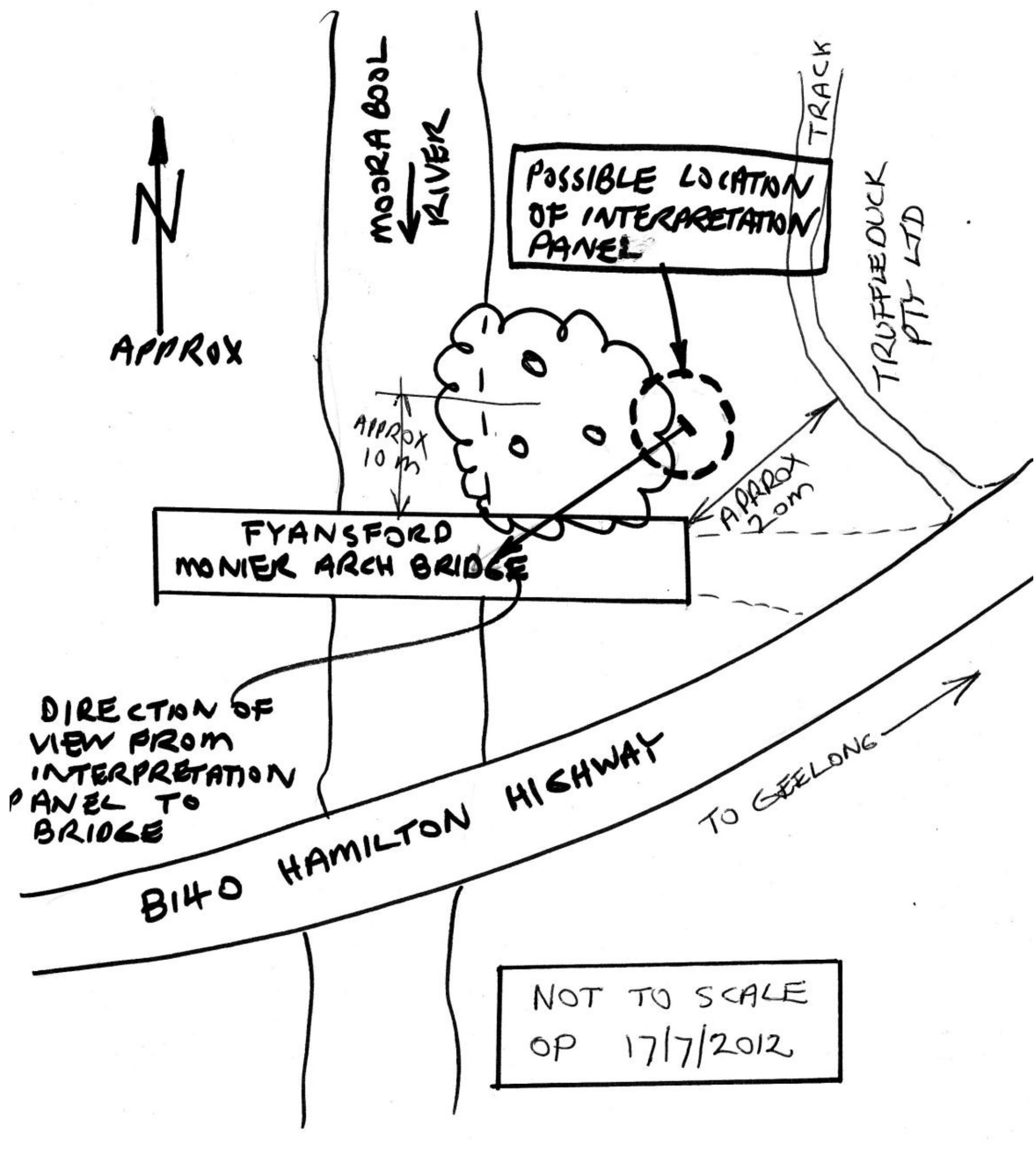
1) A title: **"Fyansford Bridge".**
2) A subtitle: **"A Pioneer of the Monier Concrete Arch Construction Method".**
3) Logos of Engineers Australia, VicRoads & City of Greater Geelong.
4) A small scale representation of the EHA marker plate.
5) The date and other details of the marking ceremony.
6) A web site reference to the availability of the full nomination on the EHA web page.
7) Text for main text panels should be 30 point Arial Bold.
8) Minimum text size should be 24 point Arial Bold.
9) No map will be required on this panel.
7) Historic photographs will be used to illustrate the panel. Many historic photographs exist. Brief captions for each photograph and source references to be used with each photograph.
8) Original drawings exist and copies may be incorporated into the panel.

The interpretation panel will technically be constructed and erected as follows:

1) Size to be nominally 1200 mm wide by 600 mm high.
2) The panel to be constructed of vitreous enamel-on-steel plate with flanges as per drawing at Appendix 9.
3) The panel to be mounted on a steel free-standing frame as per Appendix 9.
4) The EHA marker (Engineering Heritage Marker) to be mounted below the interpretation panel as shown in Appendix 9.

The location of the interpretation panel has not yet been agreed with the owner of the land on which it is to be erected however it is likely to be placed on the east bank of the river upstream from the bridge. This will provide a view of the bridge similar to that on the cover of this document. The downstream side of the bridge is significantly obscured by the new highway bridge and the west bank of the river on the upstream side is covered with heavy scrub which makes a clear view of the bridge problematic. There are adequate public areas which would not introduce traffic hazards in the vicinity proposed.

The proposed location is shown on the diagram below. This plan has been drawn from satellite images and needs to be refined by a site visit before seeking approval from the land owner which is probably the City of Greater Geelong Council. Note that the panel is likely to be located at least 10 metres from the nearest point of the bridge structure.



The panel will be mounted so that the bridge is in full view when the observer looks up from reading the interpretation panel.

The marker will be mounted on the crossbar of the interpretation panel stand and measures will be taken to secure it against removal by vandals.

7.4 Design Process for the Panel Content

The nomination will be reviewed during its development by the following parties:

1) The 10 members of the committee of Engineering Heritage Victoria

2) The Geelong Regional Group of Engineers Australia Victoria Division

3) The organisers of the Victoria Division Country Weekend to be held in Geelong

4) Mr Richard Venus, who is also the selected professional graphic designer for the project.

The design of the interpretation panel will be developed to the initial concept stage as part of the nomination writing process. It will then be further developed to a draft panel status by Richard Venus followed by review by the above reviewers plus the Heritage Recognition Committee and the site owner.

Manufacture will then be carried out by Glass Metal Industries, subject to availability of sufficient funding with the fall-back position being manufacture using vinyl film on aluminium by Advanced Group, Melbourne.

7.5 Funding

Funding for the interpretation panel is expected to be required as follows:

Graphic Design including purchase of photographic rights	$500
Manufacture of panel by Glass Metal Industries	$1400
Manufacture of Stand	$800
Installation of panel stand and panel	$500
Supply from stock of marker by EHA (EHA National Budget)	$150
TOTAL	$3350

City of Greater Geelong has already agreed to provide some funding. An amount of $3000 was discussed but not firmly agreed. City of Greater Geelong is looking at the possibility of fabricating the panel stand.

VicRoads have not yet been approached. Other discussions with VicRoads reveal that their budgets have been heavily curtailed and this particularly applies to public relations and related costs.

EHA National Budget will be asked to contribute the cost of graphic design and the provision of the marker. Funds are also available from the EHV budget for heritage recognition ceremonies costs if required.

7.6 Draft Interpretation themes for Interpretation Panels

In accordance with good interpretation practice the content of the panel will be divided into three themes for ease of understanding by the public. The following have been assessed as possible themes for the interpretation panel:

a) The development of Monier arch bridges

b) The history of the Fyansford Bridge

c) The role of John Monash and Joshua Anderson

Total text should not exceed 500 words excluding headings.

7.7 Preliminary Text Blocks for Interpretation Panels

From flower pots to bridges

The Monier system of construction using concrete reinforced with a mesh of thin steel rods was patented by Joseph Monier in France in 1867 initially for constructing flower pots and garden furniture. The technique was soon applied to arch bridges. The patent was purchased by G A Wayss in Germany and came to Australia via W J Baltzer. The firm of Carter Gummow & Co in Sydney acquired the rights to build Monier bridges in Australia. In 1897 Monash & Anderson forged a link with Carter Gummow & Co and obtained sole rights to the Monier patent in Victoria.

Monash & Anderson built 18 Monier arch bridges in Victoria up to 1905.

112 words

Building the Fyansford Bridge

Negotiations between Monash & Anderson and the Shire Councils of Corio and Bannockburn, which shared responsibility for the bridge across the Moorabool River, commenced in 1897. Construction commenced in February 1899 and proceeded quickly despite some difficulties in finding good foundations for the piers and abutments. The reinforced concrete arches on the downstream side of the bridge were cast in August 1899 and the upstream side in October 1899. The bridge was approaching completion in December 1899 and traffic started to use it however it was not tested until February 1900.

Unfortunately there was dispute over the payment for the bridge and Monash & Anderson commenced legal action against the councils in June 1901. This went in favour of Monash & Anderson however the councils still did not pay, the case went to appeal and Monash & Anderson lost the appeal. They wanted to appeal at the Privy Council but their financial resources were exhausted.

The bridge has had very little work on it since construction and carried the Hamilton Highway for 70 years before the construction of a new road traffic bridge, also of reinforced concrete, in 1970. The old bridge remains in service, carrying pedestrian and bicycle traffic.

200 words

John (later General Sir John) Monash (1865 - 1931)

During his early career John Monash worked for several organisations then formed the Monash & Anderson partnership.

In 1905 he started the successful Reinforced Concrete & Monier Pipe Construction Company with two partners, David Mitchell and John Gibson. This company continued to develop the use of reinforced concrete in Victoria.

Following a brilliant military career in World War I he became Chairman of the State Electricity Commission of Victoria and led the effort to use Latrobe Valley brown coal to generate electricity.

82 words

Joshua Thomas Noble Anderson (1865 - 1949)

John Monash's subsequent fame as a military commander overshadowed the contribution made by Joshua Anderson to engineering in Victoria and to Monash's early career.

The pair formed a business partnership in 1894 and carried out a great deal of work in various disciplines.

By 1902 a downturn in the economy and two serious misfortunes had placed the partnership in severe financial trouble. Anderson elected to take up a salaried position in charge of a sewerage scheme for Dunedin, New Zealand.

Anderson later returned to Australia and spent the rest of his life in municipal engineering in Victoria, while retaining his independence as a consulting engineer.

105 words

Total word count = 499.

8 References:

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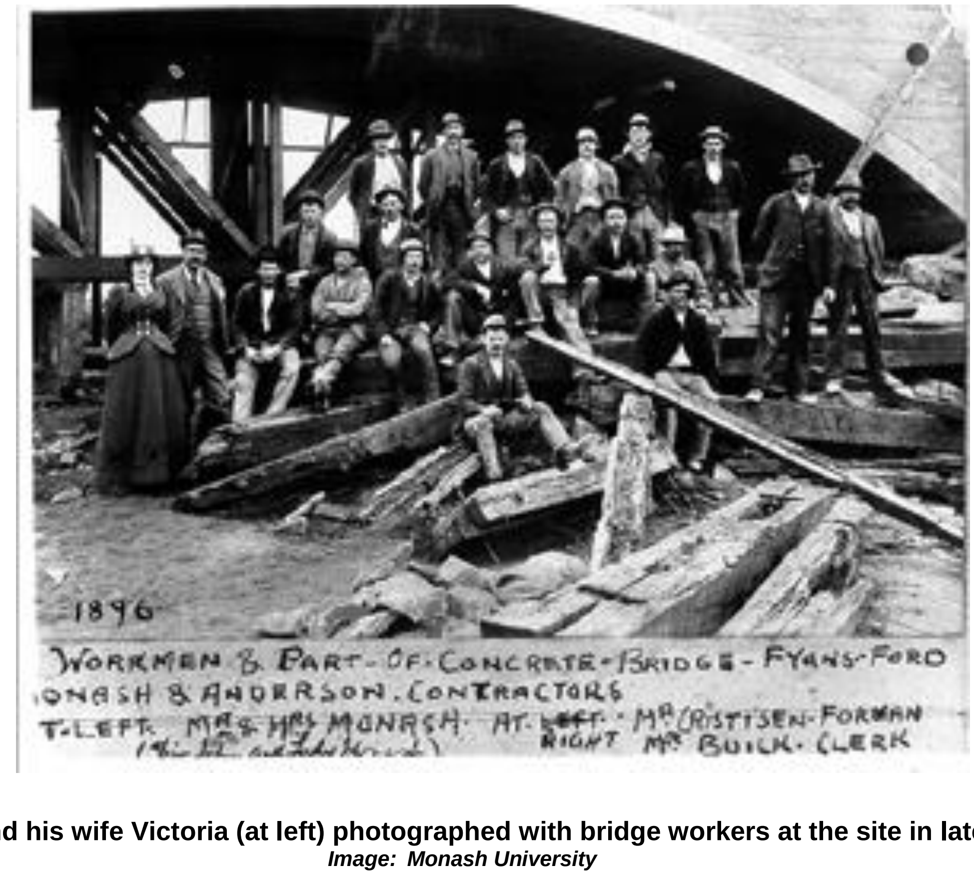
Appendix 1: Images with captions

Casting[31] the central span of the Fyansford Bridge in 1899. Note that concrete is being wheel barrowed from the river bank where it was mixed via elevated staging.
Image: University of Melbourne



Monash and his wife Victoria (at left) photographed with bridge workers at the site in late 1900.
Image: Monash University

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[31] The term "turning" was used for this process at the time. Chamber's Technical Dictionary of 1954 defines the term as follows: "A term applied to the process of building an arch".

Dedication stone on the Fyansford Bridge. See Appendix 2 for transcript of the text.
Image: Marcus Wong Wongm

Fyansford Bridge in 1910
Image: Tom Roberts AM

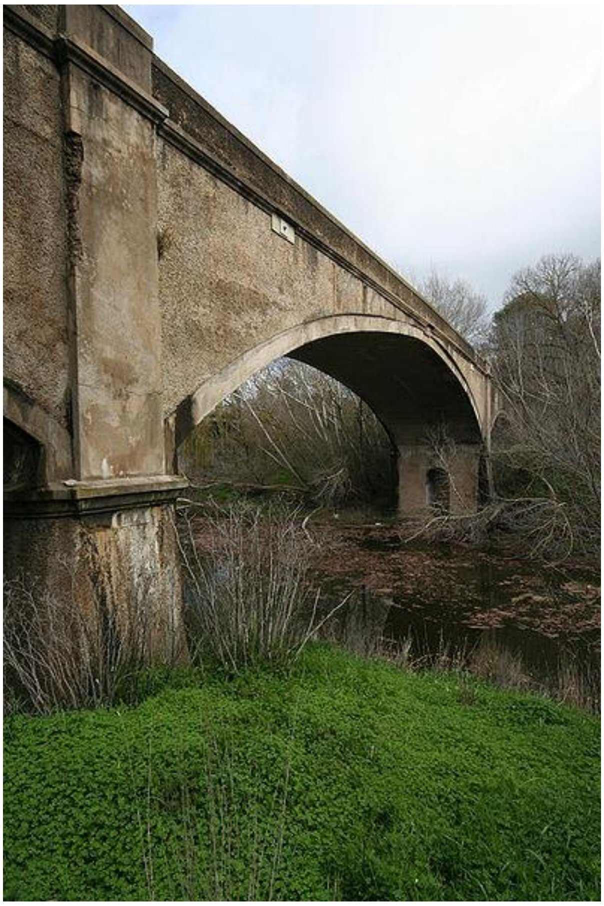
The Monash and Anderson Families 1897.

Left to right: Monash and Anderson standing.
The ladies are Victoria Monash and Ellen Anderson.
Alan Holgate thinks that this is Anderson's brother Jack.
The boy must be the Anderson's son, Stewart, born May 1893.
The girl on the left is Bertha Monash, born January 1892.
The girl on the right must be Frances Anderson, born November 1894.
The baby must be Alice Anderson, born June 1897.
Image: National Library of Australia

Fyansford with the cement works on the hillside behind. Date unknown.
Image: www.brawlerMatrix.com

The Centre span of the Fyansford Bridge from the new road bridge.
Image: Flickr

Fyansford Bridge centre span looking towards the new road bridge.
Image: Flickr



Fyansford Bridge centre span.
Image: Wikimedia Commons, Marcus Wong Wongm

The deck of Fyansford Bridge looking west towards the old Fyansford Hotel.
The dedication stone is on the right of this image.
Image: Skyscraper City Forums, Bridges of Australia

Appendix 2: Heritage Overlay File, City of Greater Geelong, Old Fyansford Bridge (Bridge over Moorabool River 1900) [32]

Location

2005 Hamilton Highway FYANSFORD, Greater Geelong City

Victorian Heritage Register (VHR) Number

H1108

Heritage Overlay Number

HO88

For further details, contact the local council or go to Planning Schemes Online.

Level of Significance

Registered

Statement of Significance

A Listed - State Significance

HISTORIC PLACES DOCUMENT SHEET - GRC SHEET NO 13

STATEMENT OF SIGNIFICANCE

The Fyansford Bridge, erected in 1899 and opened for traffic in February 1900, is the first bridge in Victoria completed using the new reinforced concrete technique developed in Europe and known as the 'Monier' principle Sydney engineers Gummow and Carter introduced the system to Australia and leading Victorian engineering's John Monash and J.T.N. Anderson pioneered this work in Victoria. The Fyansford Bridge is or paramount importance to this history of technology in Australia which finely defined proportions over the three spans of arches contributing to its notable aesthetic qualities.

RECOMMENDATIONS: PROTECTIVE MEASURES

Geelong Regional Commission Register

Historic Buildings Council Register

Australian Heritage Commission Register of the National Estate

[32] Note that the document is reproduced as published, including errors, except where noted.

REFERENCES

Alsop, P.F. Notes on National Trust of Victoria, File No. 2841

Geelong Advertiser - 17th February, 1900.

'Memorial Stone Inscription'

AD 1900

THE FIRST MONIER[33] BRIDGE

IN THE WESTERN DISTRICT OF VIVTORIA

FOR

THE SHIRES OF BANNOCK BURN AND CORIO

W.H. JONES

PRESIDENT. BANNOCKBURN SHIRE

JAMES CAMPBELL, PRESIDENT CORIO SHIRE

SAMUEL MORRIS AND JAMES BLAIR

SECRETARIES

A. L. CAMPBELL

SUPERINTENDING ENGINEERS

ERECTED BY MONASH AND ANDERSON

History

iBDThe plaque on the bridge reads: "A.D. 1900 The First Monier Bridge in the Western District of Victoria for the Shires of Bannockburn and Corio. W.H. Jones, President, Bannockburn Shire, James Campbell, President, Corio Shire. Samuel Morris and James Blair Secretaries. A.L. Campbell, Superintending Engineers. Erected by Monash and Anderson." Refer to A. Willingham, Geelong Region Historic Buildings and Objects Study, vol.1, sheet 13.

HISTORY

STYLE OF PERIOD: Industrial/Engineering Structure

ARCHITECT(S)/DESIGN ORIGIN:

[33] The spelling of the word "Monier" has been corrected here to line up with the actual wording on the panel as opposed to the publication in the Heritage Overlay.

Monash & Anderson Engineers

Ref: Alsop, P.F.

Unpublished research on National Trust File No. 2841

BUILDER: Monash and Anderson, Engineers

DATES OF CONSTRUCTION:

Contract Signed March 1899

Contract Completed Feb. 1900

Tested 16th February, 1900

Ref: Alsop P.F.

SUBSEQUENT WORKS/ALTERATIONS/ADDITIONS:

Superceded 1970 by new bridge which by-passes the old bridge.

ORIGINAL OWNERS/OCCUPANTS: Shires of Bannockburn and Corio

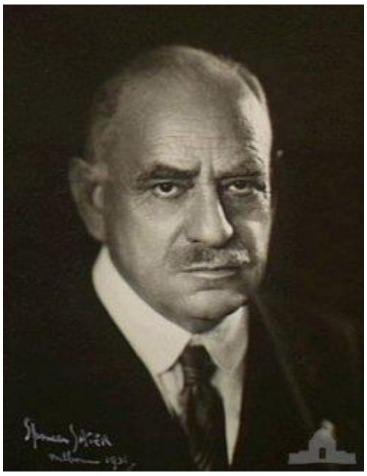
OTHER NOTES: First re-inforced concrete arch bridge available use in Victoria.

Description

Heritage Study	**Greater Geelong - Geelong Region Historic Buildings and Objects Study, Allan Willingham, 1986**
Heritage Act Categories	**Heritage object/s**
Municipality	**GREATER GEELONG CITY**

Appendix 3: Historic Individuals or Associations

A3.1 Sir John Monash (1865–1931) [34]



Sir John Monash

"John Monash was born in Melbourne on 27 June 1865 into a Prussian-Jewish family. He was educated at Scotch College and Melbourne University. By 1895 he had degrees in arts, engineering and law and had qualified as a municipal surveyor, an engineer of water supply and a patent attorney. As an engineer Monash's early career was in bridge construction working for a time with the Melbourne Harbour Trust, before becoming a partner in a bridge building firm. By the turn of the century his focus had changed to building construction. Monash's military career began in 1884 with his membership of the Melbourne University company of the 4th Battalion, Victoria Militia, and then moving to the North Melbourne Battery of the Metropolitan Brigade of the Militia Garrison Artillery. He was commissioned in 1887. By 1913 Monash had the rank of Colonel and was appointed to command the 13th Infantry Brigade. With the outbreak of World War I in 1914, Monash was transferred from the militia to active service. In 1915 he served as Chief Censor until taking command of the 4th Infantry Brigade (AIF). In this command he served at Gallipoli.

[34] National Archives of Australia, http://www.naa.gov.au/aboutus/publications/factsheets/fs121.aspx, 1997. This document was copied from the Engineering Heritage Victoria Nomination for the Yallourn Power Station by Udara Almeida, 2011.

Promoted to Major-General, he commanded the 3rd Division, AIF in France in 1916. Monash succeeded General Birdwood as Australian Corps commander in 1918 and, in the same year, was knighted by King George V in recognition of his role in the Battle of Hamel Hill. With the conclusion of the war, Monash became Director-General of Repatriation and Demobilisation with responsibility for arranging the return of Australian troops from Europe. Back in Australia Monash resumed his engineering career firstly as General Manager and later as Chairman of the State Electricity Commission (SEC) of Victoria. Under his leadership the SEC became an important body in developing Victoria's brown coal reserves as an electricity source and, by 1930, extending the power grid across the whole of the State.

John Monash died in Melbourne on 8 October 1931."

A3.2 Joshua Thomas Noble Anderson (1865-1949) [35]

"John Monash's subsequent fame overshadowed the contribution made by J. T. N. Anderson to engineering in Victoria and to Monash's early career. The pair formed a business partnership in 1894. In 1897, while Monash was in Western Australia, Anderson forged a link with the Sydney firm of Carter Gummow & Co and obtained through them sole rights to the Monier patent in Victoria. He oversaw the initial negotiations, planning and design for the partnership's first two Monier arch bridges (Fyansford and Wheeler's); obtained many of their commissions and contracts; and consulted widely in the fields of mechanical engineering, water resources and mining. By 1902 a downturn in the economy and two serious misfortunes had placed the partnership in severe financial trouble and its future was uncertain. Anderson elected to take up a salaried position in charge of design and construction of a new sewerage scheme for Dunedin, New Zealand. It is likely that the pair hoped to form a bridgehead there for the partnership and its related pipe factory, though nothing eventuated. Monash worked in Victoria at trading the firm out of debt and in 1905 it was agreed that the partnership be dissolved. Anderson relinquished his rights and was absolved from his share of the remaining debt. He travelled overseas for some time, then returned to Australia and spent the rest of his life in municipal engineering in Victoria, while retaining his independence as a consulting engineer". [36]

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[35] Alan Holgate Vicnet web site downloaded 10 July 2012.

[36] Anderson's life is summarised in a paper by Brian Lloyd. Stories of the bridge projects in which JTNA was concerned are available on the Alan Holgate web site via the following links: Morell Bridge; Fyansford Bridge; Wheeler's Bridge; Bendigo Arch Bridges; Kings Bridge, Bendigo; Barbers Creek Bridge and Woolert Bridge. There is much more in the archives at UMA and NLA on JTNA's consulting work, e.g. for the Mildura Irrigation Board and the Ballarat Woollen Mills.

A3.3 Joseph Monier (1823 - 1906) [37]

"Monier was born in Saint Quentin la Poterie, France and became a renowned French gardener and one of the principal inventors of reinforced concrete.

As a gardener, Monier was not satisfied with the materials available for making flowerpots. Clay was easily broken and wood weathered badly and could be broken by the plant roots. Monier began making cement pots and tubs, but these were not stable enough. In order to strengthen the cement containers, he experimented with embedded iron mesh. He was not the first to experiment with reinforced concrete, but he saw some of the possibilities in the technique, and promoted it extensively.

Monier exhibited his invention at the Paris Exposition of 1867. He obtained his first patent on July 16, 1867, on iron-reinforced troughs for horticulture. He continued to find new uses for the material, and obtained more patents — iron-reinforced cement pipes and basins (1868); iron-reinforced cement panels for building façades (1869); bridges made of iron-reinforced cement (1873); reinforced concrete beams (1878). In 1875 the first iron-reinforced cement bridge ever built was constructed at the Castle of Chazelet. Monier was the designer.

The important point of Monier's idea was that it combined steel and concrete in such a way that the best qualities of each material were brought into play. Concrete is easily procured and shaped. It has considerable compressive or crushing strength, but is somewhat deficient in shearing strength, and distinctly weak in tensile or pulling strength. Steel, on the other hand, is easily procurable in simple forms such as long bars, and is extremely strong. But it is difficult and expensive to work up into customized forms. Concrete had been avoided for making beams, slabs and thin walls because its lack of tensile strength doomed it to fail in such circumstances. But if a concrete slab is reinforced with a network of small steel rods on its undersurface where the tensile stresses occur, its strength will be enormously increased.

Francois Hennebique saw Monier's reinforced concrete tubs and tanks at the Paris Exposition and began experimenting with ways to apply this new material to building construction. He set up his own firm the same year and in 1892 he patented a complete building system using the material.

[37] Wikipedia, Joseph Monier, downloaded 10 August 2012.

In 1886 German engineer Gustav Adolf Wayss (1851–1917) bought Monier's patent and developed it further. He conducted further research in the use of reinforced concrete as a building material, and established the firm of Wayss & Freytag".

A3.4 Dr Alan Holgate (1937 -) [38]

The research of Dr Alan Holgate has been vital to this nomination. His material is collected together in a systematic manner on a Vicnet web site making it very accessible. All students of Monash's work are indebted to Alan for his body of work on Monash.

Alan Holgate was born at Chesterfield, Derbyshire, England in 1937. He now lives at Mooroolbark, in the outer eastern suburbs of Melbourne.

He was educated in various primary schools in Derbyshire and Devon then moved on to Newton Abbot Grammar School, studied civil engineering at University College, London, from 1955 to 1958 and obtained a BSc(Eng).

He carried out supervision of road maintenance and construction with the Department of Main Roads, New South Wales from 1958 to 1961 then worked as Office Engineer at Marples Ridgway & Partners, London from 1961 to 1962.

Returning to Australia he worked on hard rock tunnelling supervision for the Snowy Mountains Hydro-Electric Authority, Eucumbene, Australia from 1962 to 1963 then in power station design, Snowy Mountains Hydro-Electric Authority, Cooma from 1964 to 1965.

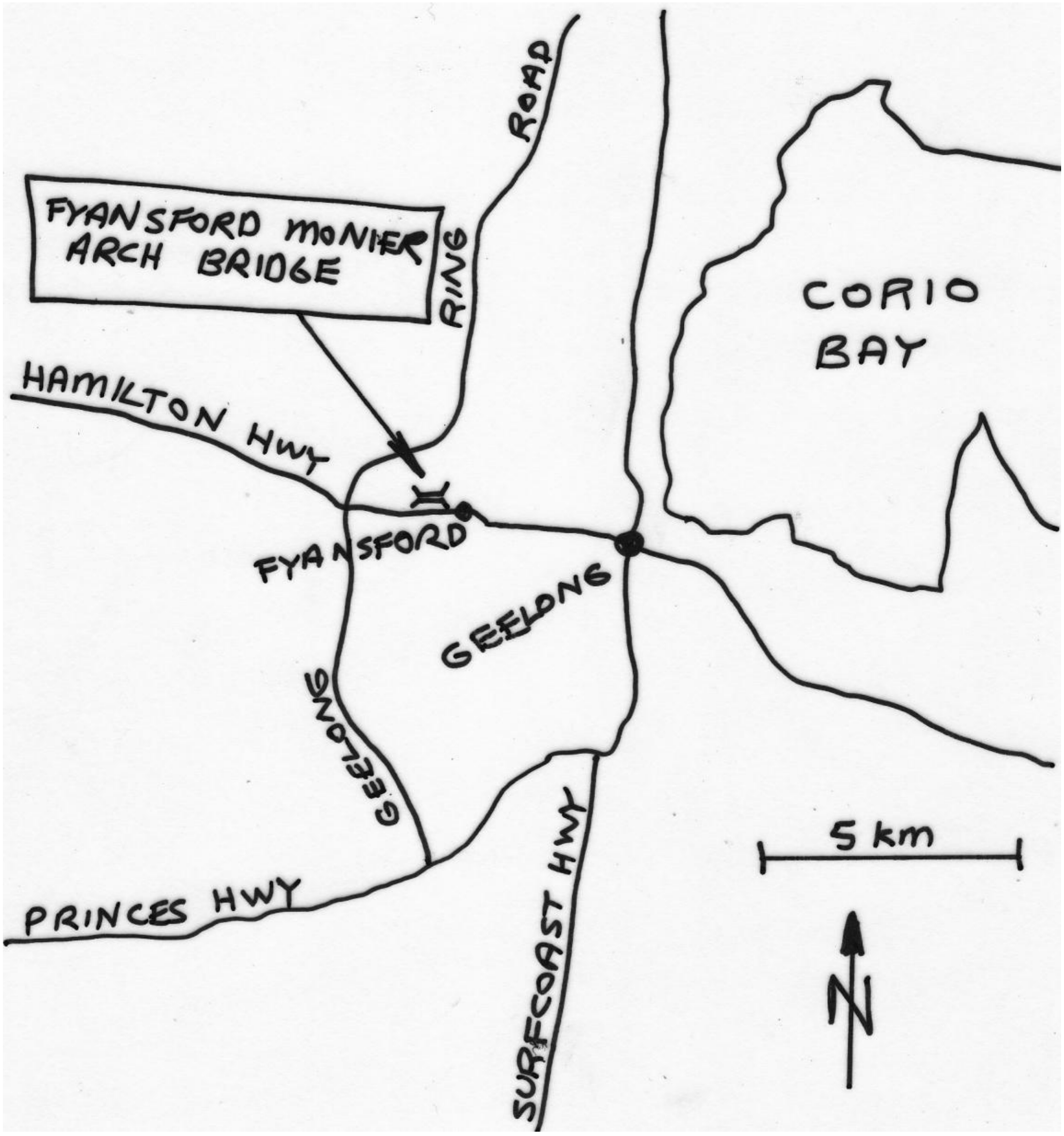
He then took up teaching and research in analysis and design of structures with the Department of Civil Engineering, Monash University, Melbourne from 1966 to 1996. During this time he was a lecturer from 1967 to 1971, Senior Lecturer from 1972 to 1993 and Associate Professor from 1994 to 1996.

He obtained his Ph.D at Monash University in 1996 and since retiring from Monash has been in Independent Scholar.

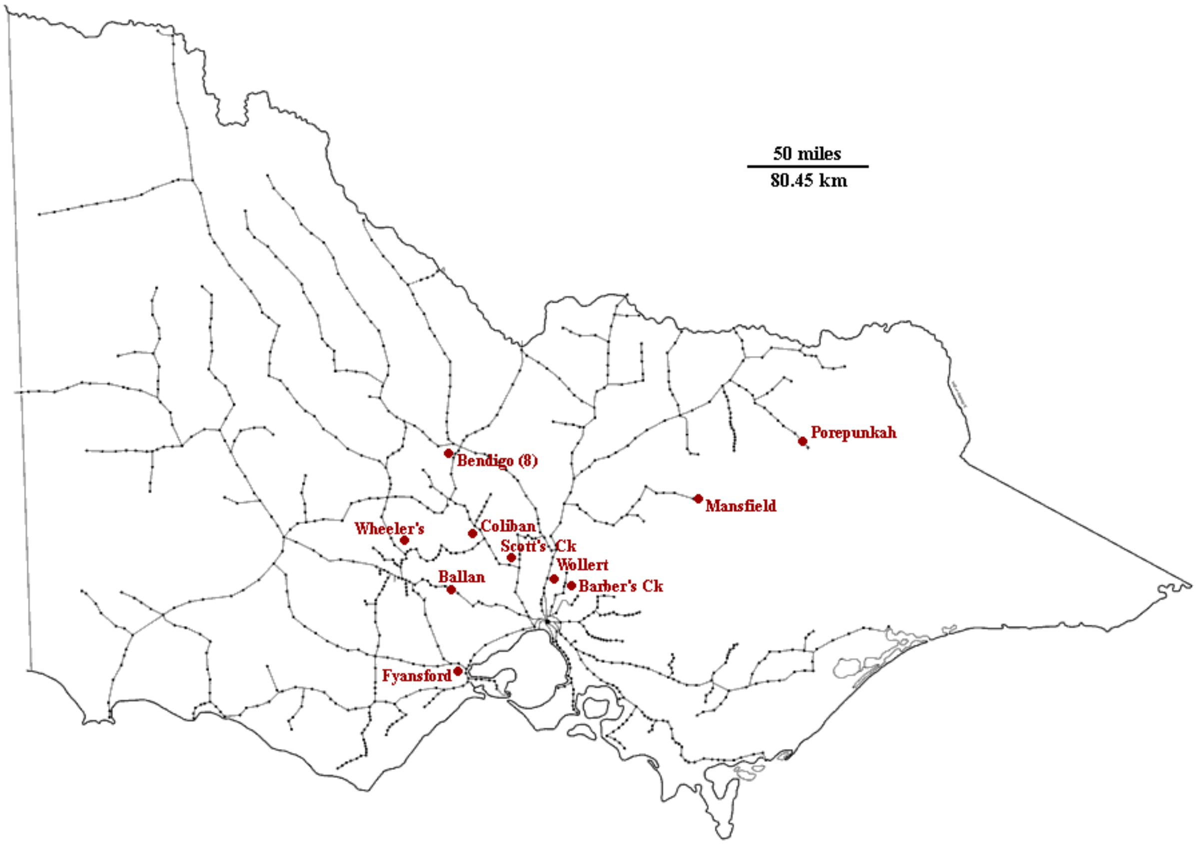
[38] Alan Holgate Vicnet web site downloaded 10 July 2012.

Appendix 4: Maps

A4.1 Location Map



A4.2 Map of Monier Arch Bridges built in Victoria. *Image: Alan Holgate Vicnet website*



Appendix 5: List of Monash & Anderson Monier Arch Bridges [39]

Bridge Name	Date	Municipality (present)	Coordinates
Anderson St. "Morell." (attributed to Carter Gummow & Co.)	1899	Melbourne.	-37.8275, 144.9850
Fyansford.	1900	Greater Geelong-Golden Plains.	-38.1420, 144.3087
Wheeler's.	1900	Hepburn.	-37.3230, 143.8916
Oak St.	1901	Greater Bendigo.	
First King's.	1901	Greater Bendigo.	
Booth St.	1901	Greater Bendigo.	-36.769847, 144.261839
High St.	1901	Greater Bendigo.	-36.769628, 144.263867
Wade St.	1901	Greater Bendigo.	-36.77042, 144.26082
Scott's Ck Culvert.	1901	Moorabool.	
Second King's. (Weeroona Ave).	1902	Greater Bendigo.	-36.74364, 144.29165
Abbott St.	1902	Greater Bendigo.	-36.758347, 144.289917
Myrtle St.	1902	Greater Bendigo.	
Thistle St.	1902	Greater Bendigo.	-36.76837, 144.26710
Barber's Creek.	1901	Whittlesea.	-37.57440, 145.10448

[39] Alan Holgate, list of Arch Bridges.

Wollert.	1901	Whittlesea.	-37.59590, 145.05357
Coliban.	1902	Macedon Ranges.	-37.284840, 144.397248
Ford's Creek.	1903	Delatite.	
Ballan.	1905	Moorabool.	
Porepunkah.[40]	1913	Alpine.	-36.69700, 146.89393

[40] This bridge was constructed well after the Monash & Anderson partnership was dissolved in 1905.

Appendix 6: Time Line for John Monash [41]

1865	Birth - 27 June, at Dudley Street, West Melbourne
1874-75	Resides with family in Jerilderie, New South Wales
1877-81	Student at Scotch College
1882	Enrols at University of Melbourne
1884	Joins University Company of the Victorian Rifles, appointed Colour-Sergeant in 1886
1884-87	Employed on construction of Princes Bridge and other bridge works in Melbourne for David Munro & Co.
1887	Commission in the Militia Garrison Artillery
1887	Takes charge of construction works for Outer Circle Railway
1891	Marries Victoria Moss
1893	Master of Civil Engineering Birth of daughter Bertha
1892-94	Assistant Engineer and Chief Draftsman of Melbourne Harbour Trust. Qualifies as Municipal Surveyor, Engineer for Water Supply and as Patent Agent
1894-1905	Private Practice (Monash and Anderson) as Consulting Engineer and Patent Attorney
1895	Awarded Bachelor of Arts and Bachelor of Laws

[41] Monash University web site downloaded 10 July 2012.

1897-99	Legal-engineering work in Queensland, New South Wales and Western Australia
1901	Monier Pipe Company Pty. Ltd. formed (Monash, Anderson and Mitchell)
1905	Reinforced Concrete and Monier Pipe Construction Company Pty. Ltd. formed (Monash and Mitchell)
1907	Takes command of Victorian Section of newly formed Intelligence Corps
1908	Promoted to Lieutenant-Colonel
1912	President of Victorian Institution[42] of Engineers
1913	Appointed Colonel and commander of 13th Infantry Brigade in Victoria
1914	Leaves Australia in command of 4th Infantry Brigade, Australian Imperial Force
1915	Promoted to Brigadier-General
1916	Promoted Major-General in command of new 3rd Division
1918	Knighted by King George V
1918	Appointed Australian Corps Commander and promoted to Lieutenant-General
1919	Returns to Australia
1920	Death of Victoria Monash Appointed General Manager of the State Electricity Scheme

[42] Institute corrected to Institution for clarity.

1921	Awarded Doctor of Engineering Appointed Chairman State Electricity Commission
1921-31	Oversees design and construction of Shrine of Remembrance
1923	Chairman of Royal Commission into police strike
1923-31	Vice-Chancellor of the University of Melbourne
1929	Promoted to General Awarded Peter Nicol Russell Memorial Medal[43] (Institution[44] of Engineers, Australia)
1930	Awarded Kernot Memorial Medal (University of Melbourne) for brown coal development
1931	Death - 8 October

[43] Often referred to as the Peter Nicol Russell Medal.

[44] Institute corrected to Institution for clarity.

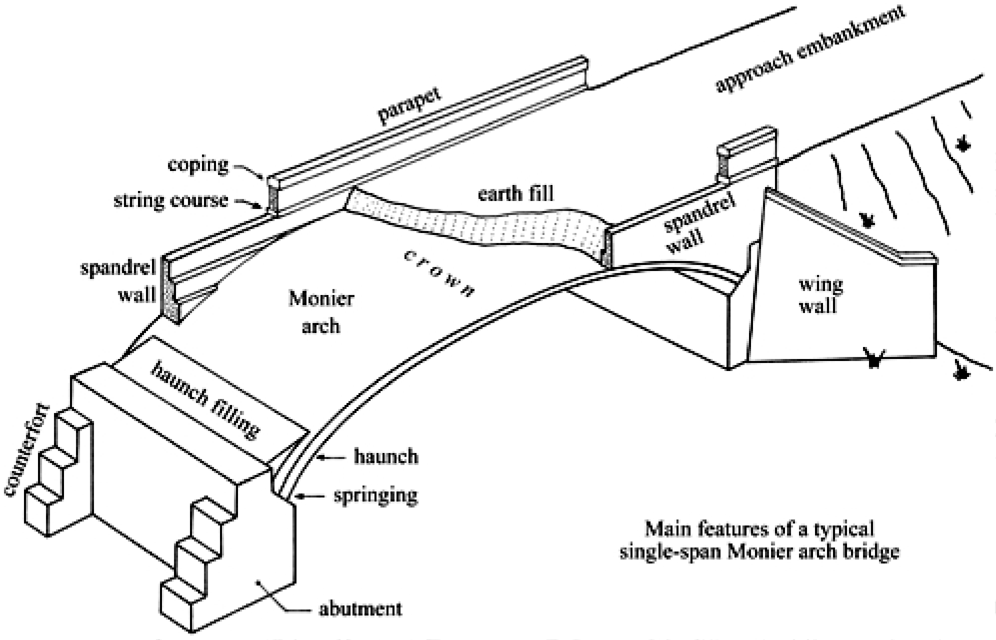
Appendix 7: Time Line Fyansford Bridge

5 October 1897	Anderson investigated site conditions and sent preliminary sketch to Gummow in Sydney.
November 1897	Anderson made initial quote for £3850.
March 1898	Revised quote made based on drawings of £4700
July 1898	Monash went to Perth for court case and was away from Melbourne for a year.
December 1898	Monash & Anderson offered to build the bridge as originally designed for £4530.
December 1898	Monash & Anderson submitted further revised quote of £4347.
January 1899	Anderson warned councils that price would have to be increased after this date on account of having to work through the winter.
14 January 1899	Meeting between councils was described as "fiery" and causing "ruptured relations between the two councils".
24 January 1899	Corio Council decided it would adopt a wooden bridge for the site.
31 January 1899	Joint meeting of councils to discuss the bridge.
4 February 1899	Councils agreed to details of the contract conditions.
23 February 1899	Excavations commenced.
21 March 1899	Concreting of first pier commenced.
29 March 1899	Meeting to finalise terms of contract.
12 April 1899	Monash left again for Perth.
Early May 1899	Piers were almost complete.
20 June 1899	Abutments 87.5% complete.
23 June 1899	Monash & Anderson finally receive a copy of the specification.
4 July 1899	Monash returns from Perth.

8 July 1899	Committee recommended payment of a large progress payment of £1120.
14,15, 16 August 1899	Downstream half of the three arches were cast.
12 September 1899	Monash & Anderson protested delays in making decisions and making progress payments.
11. 25. 26 October 1899	Upstream half of the three arches were cast.
End November 1899	Centring had been struck and filling completed.
December 1899	Traffic began to use the bridge unofficially.
16 February 1900	Bridge tested satisfactorily.
2 August 1900	Further Joint Conference of parties due to the non-payment of contractors claims.
17June 1901	Commencement of hearing before Justice Williams.
December 1901	Shires had not paid the sum awarded and the Sheriffs seized the contents of the two town halls.
May 1902	Anderson accepted salaried position as Chief Engineer of the Sewerage Board of Dunedin, New Zealand.
4-13 February 1902	Appeal hearing.
31 December 1902	Monash having second thoughts about the lodging of an appeal with the Privy Council.
28 April 1903	Monash stated in his diary “Fyansford case settled”.
December 1905	Concern about bulging of spandrel walls. Rectification work was subsequently carried out.
1905	Monash & Anderson partnership dissolved.

Appendix 8: Basic calculations for Monier arch bridges as carried out by Monash & Anderson. [45]

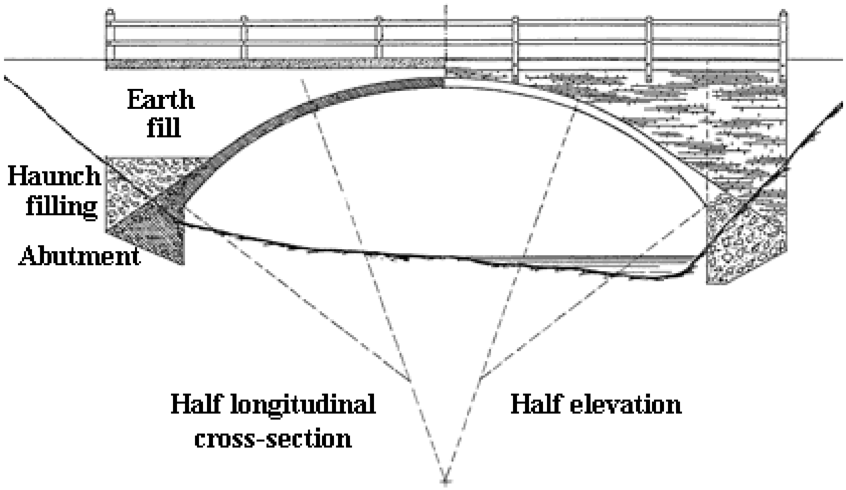
This web page is devoted to the procedures used by Monash and Anderson, and their engineering assistants, to determine the profile for a Monier arch, and to calculate the resulting forces and stresses. It assumes that the reader has some basic knowledge of the mechanics of structures. It is restricted to the techniques used for M&A's early bridges, which were checked only for symmetrical uniformly distributed live load. The Upper Coliban Spillway Bridge is used as an example. Computations were sent to Sydney to be checked by W. J. Baltzer and F. M. Gummow. Baltzer had earlier used more complex procedures for the design and analysis of the Anderson Street (Morell) Bridge. After the collapse of the first King's Bridge at Bendigo, Monash obtained from him details of procedures for analysis for non-symmetrical and point loads, the most important 'point' loads being the axles of the steam rollers used in testing the bridges.



Main features of a typical single-span Monier arch bridge

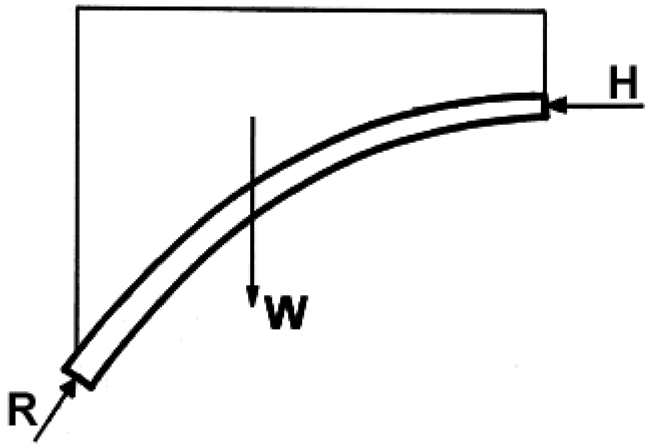
The process used for design was a sort of 'form-finding'. At this early stage in the development of reinforced concrete, M&A and their advisors were unaware of any method for taking into account the presence of the reinforcement in an arch cross-section subjected to combined axial load and bending moment. The grids of small diameter bars provided in the Monier system were therefore ignored in analysis, and the aim was to shape the curve of the arch to avoid tensile stresses under normal loading conditions. This was achieved by ensuring that the centreline of the profile coincided with the line of thrust due to the self weight of the arch, spandrel walls and filling. (Sometimes live load was included at this stage.) Checks were then made on varying live load conditions applied to the chosen form, to ensure that the thrust line did not deviate greatly from the centreline. Because the self weight of the bridge was enormous in comparison with the live load, this was rarely a problem in theory. (In practice it turned out that the arch curve as built often deviated considerably from the theoretical curve owing to deflection and subsidence of falsework, and this was a much more significant cause of bending stress.)

[45] Alan Holgate Vicnet web site downloaded 10 July 2012.

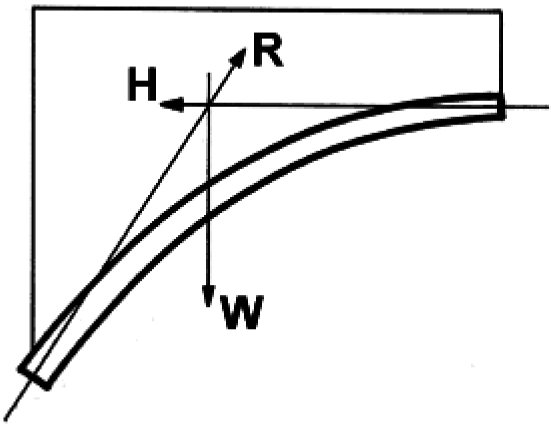


The left-hand side of the above drawing shows half of the longitudinal cross-section of a typical Monier arch bridge. The right hand side shows half of the side elevation. The arch profile is made up of three circular segments, as indicated by the radii. This is a simplified version of part of the working drawing for Ford's Ck Bridge, Mansfield. For a more complete extract click here.

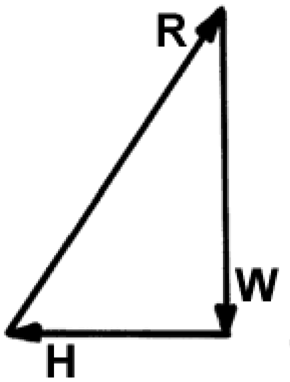
The process of form-finding was iterative. All bridges were assumed symmetrical about the vertical centreline of the elevation, so that one half of the span could be treated as a 'free body' subjected to three forces: W, the total weight; R, the inclined reaction from the abutment; and H, the thrust in the crown exerted by the other half of the bridge.



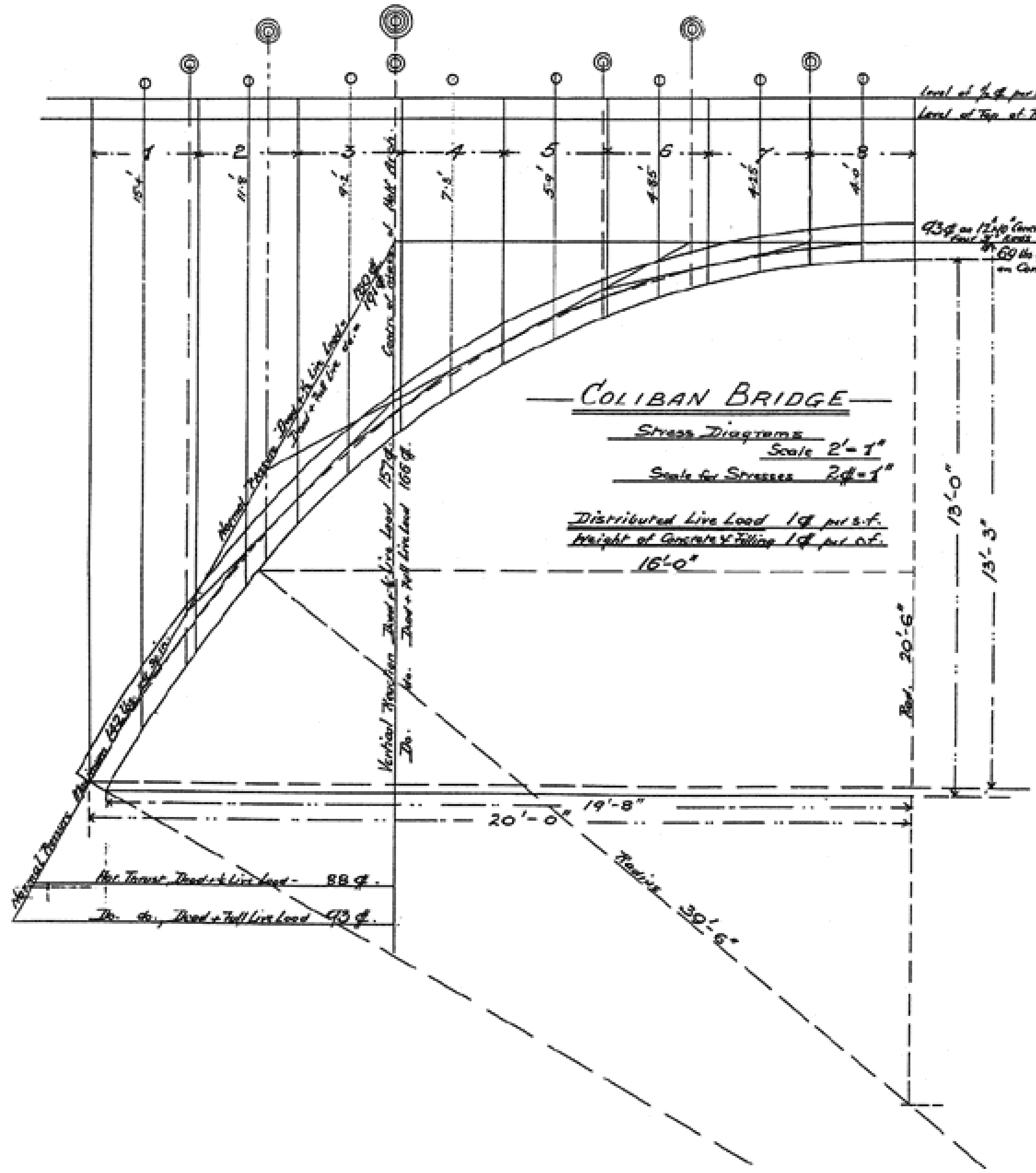
Because of the symmetry, and in the absence of a point load at the crown, H was horizontal. Assuming that the desired form had already been found, both H and R would pass through the centreline of the arch thickness, while W passed through the centroid of the half-arch. The lines of action of three forces which are in equilibrium intersect. Thus R passed through the intersection point of W and H.



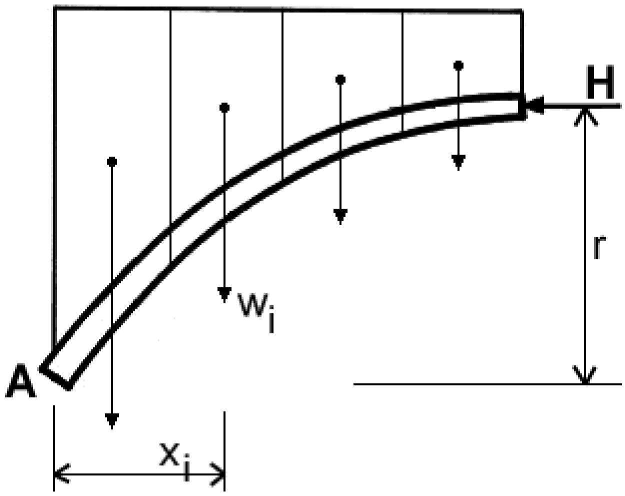
Hence a triangle of forces could be drawn. This gave the direction of R, while the magnitude of R and H could be determined by scaling from the known value of W. (H could also be obtained by taking moments about the abutment.)



This approach is evident in the drawing which J. S. Gregory produced for the Upper Coliban Spillway Bridge. (see below)



In the actual calculation process, the spandrels and fill above the half-arch were conceived as broken into segments by taking vertical slices across the width of the bridge. For clarity, only four are shown in the figure below, but normally eight were taken. It was customary to work with a strip of arch adjacent to the edge and one foot wide. The weight of the live load, when included, was indicated on the drawings as a surcharge comprised of an equally heavy volume of fill. In the Coliban calculations it appears that when the weight of a segment was calculated the specific weights of reinforced concrete, mass concrete, and earth fill were simply taken as a uniform 1 cwt force (112 lbf) per cubic foot (17.6 kN/m^3). When the arch was considered by itself (supporting its own weight during construction, or for an alternative scheme with timber superstructure) the specific weight of 'Monier' was taken as 150 lbf per cubic foot.



Taking moments about the springing point A:

$H\ r = Sum\ (w_i\ x_i)$

thus
$H = (\ Sum\ w_i\ x_i\ )\ /\ r$

This approach is evident in the tabular calculations represented below. The same tables permitted the calculation of the total mass above the half-arch (Sum w_i) and the position of its centroid so that the location of the force W could be established.

In the table reproduced below, the effective half-span is taken as 20.08 feet and is split into eight vertical segments each of width K = 20.08 / 8 = 2.51 feet. The centre of gravity of each segment lies at the centroid of its area as seen in elevation. This is assumed to be midway between its vertical edges. The distances from the springing point to each centroid are expressed throughout in terms of K. For a one-foot wide slice in the direction of the span, the volume of each segment is one foot multiplied by its area as seen in elevation, i.e. 1 × K × (average depth). The average depths have been scaled from the drawing as 15.4, 11.8, etc. As the unit weight of all materials is taken as 1 cwt per cubic foot, the weight of a segment is simply 1 × K × (av. depth) × 1 = K × (av. depth). In column 2 the weight W of the one-foot-wide slice of the half-span is summed as 62.62 K = 157.17 cwt. Its first moment about the abutment (Column 3) is 184.29 K^2 = 1161 foot-cwt. Hence the centroid lies 1161/157 or about 7.38 feet from the abutment. With these facts it is now possible to obtain the magnitudes of H and R and the direction of R.

Final set of calculations for Coliban Spillway Bridge "accepted design" with masonry spandrels.

by J.S.Gregory, 21 August 1901 (edited for this website.)
Dead load plus half live load. Span = 39'-4", Rise = 13'.
K = 20.08 / 8 = 2.51

Column 1	Column 2		Column 3		Column 4	Column 5
Lever arm from springing.	Weight of segment.		Moment of weight about springing.		Segments grouped in twos.	Segments grouped in fours.
K × 1/2	15.40 K	27.20	7.70 K^2 17.70	25.40	25.40 K^2 / 27.20 K=	73.95 K^2 / 43.70 K =

K × 3/2	11.80 K		K^2		2.34	4.24
K × 5/2 K × 7/2	9.20 K 7.30 K	16.50	23.00 K^2 25.55 K^2	48.55	48.55 K^2 / 16.50 K = 7.38	
K × 9/2 K × 11/2	5.86 K 4.86 K	10.72	26.37 K^2 26.73 K^2	53.10	53.10 K^2 / 10.72 K = 12.43	110.34 K^2 / 18.92 K = 14.63
K × 13/2 K × 15/2	4.25 K 3.95 K	8.20	27.62 K^2 29.62 K^2	57.24	57.24 K^2 / 8.20 K = 17.52	
	62.62 K		184.29 K^2			

Distance of centre of gravity of whole from abutment point = 184.29 K^2 / 62.62 K = 7.38'
Horizontal thrust = 184.29 × 6.3 / 13.25 = 87.6 cwt.
Vertical Reaction = 157.17 cwt.

In the calculation for horizontal thrust 184.29 × 6.3 / 13.25, the 6.3 is K^2 and the 13.25 is 13'-3", the rise from the abutment "hinge" to the centreline of the arch at the crown i.e. to the level of the horizontal thrust in the crown. The vertical reaction at the abutment must equal the total weight of the segments, 157.17.

To trace the full pressure curve within the arch the vertical slices are grouped first into four groups of two (Column 4). The positions of the centres of gravity is determined for each group. In Column 5 two groups of four segments are taken. This process can be traced through the system of symbols at the top of the drawing, consisting of small concentric circles:

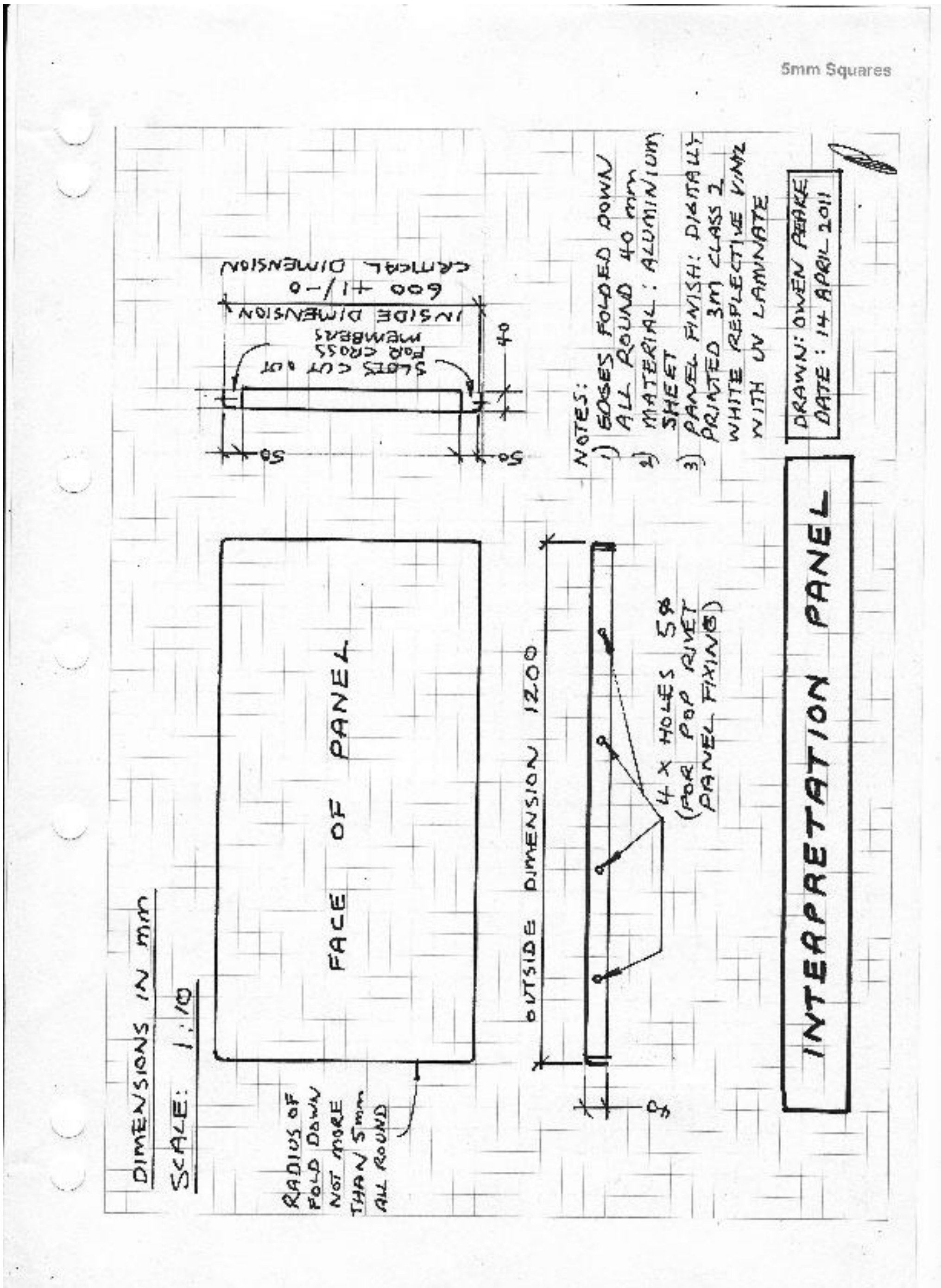
Four small circles indicate the position of the total load W. Part way down its line of action, the intersecting lines of H and R can be seen.

Three small circles indicate the weight of the two groups of four segments. The points where their lines of action cut H and R are joined by a construction line.

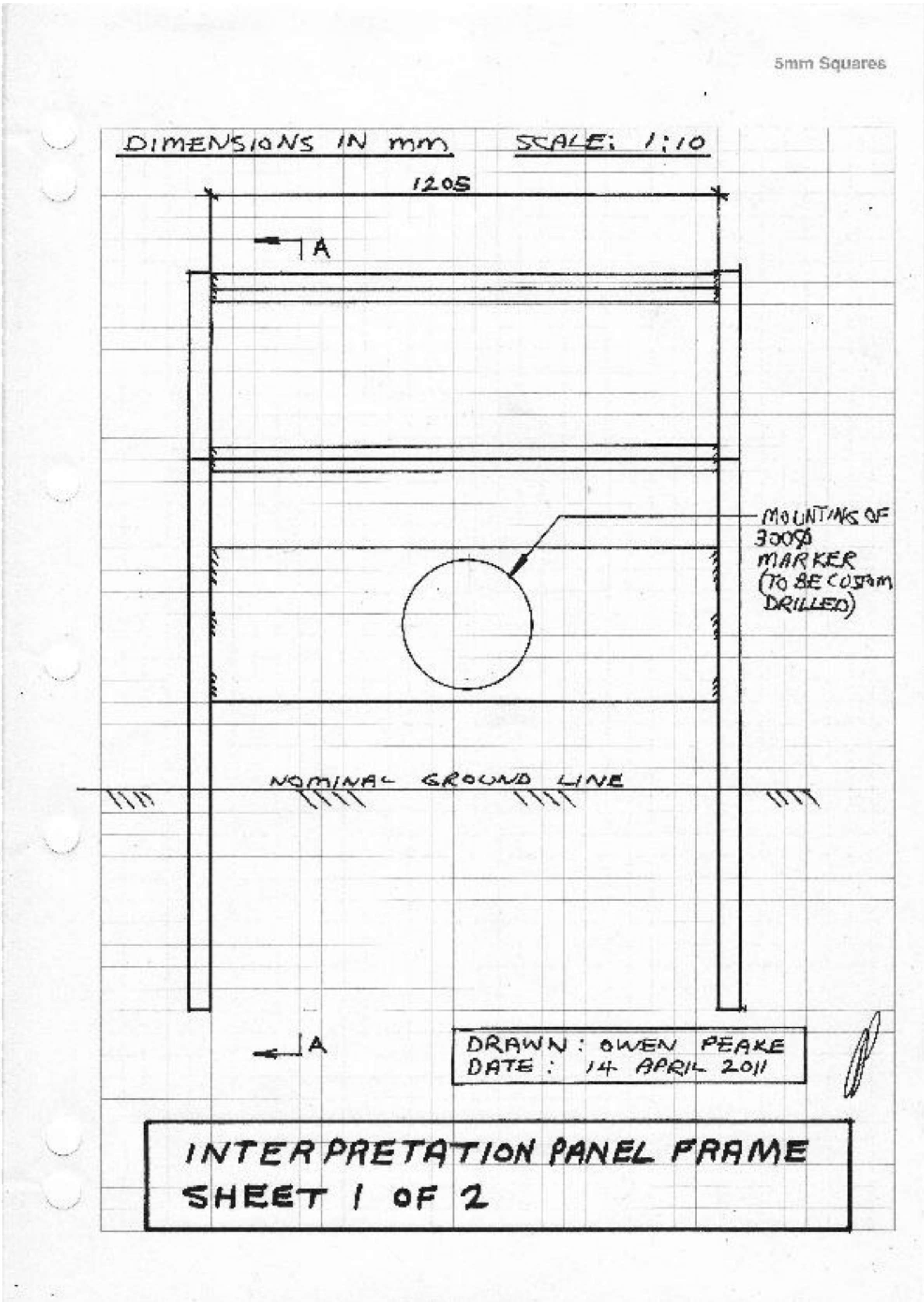
This process is repeated until the level of the individual segment is reached, resulting in the thrust line, shown dashed.

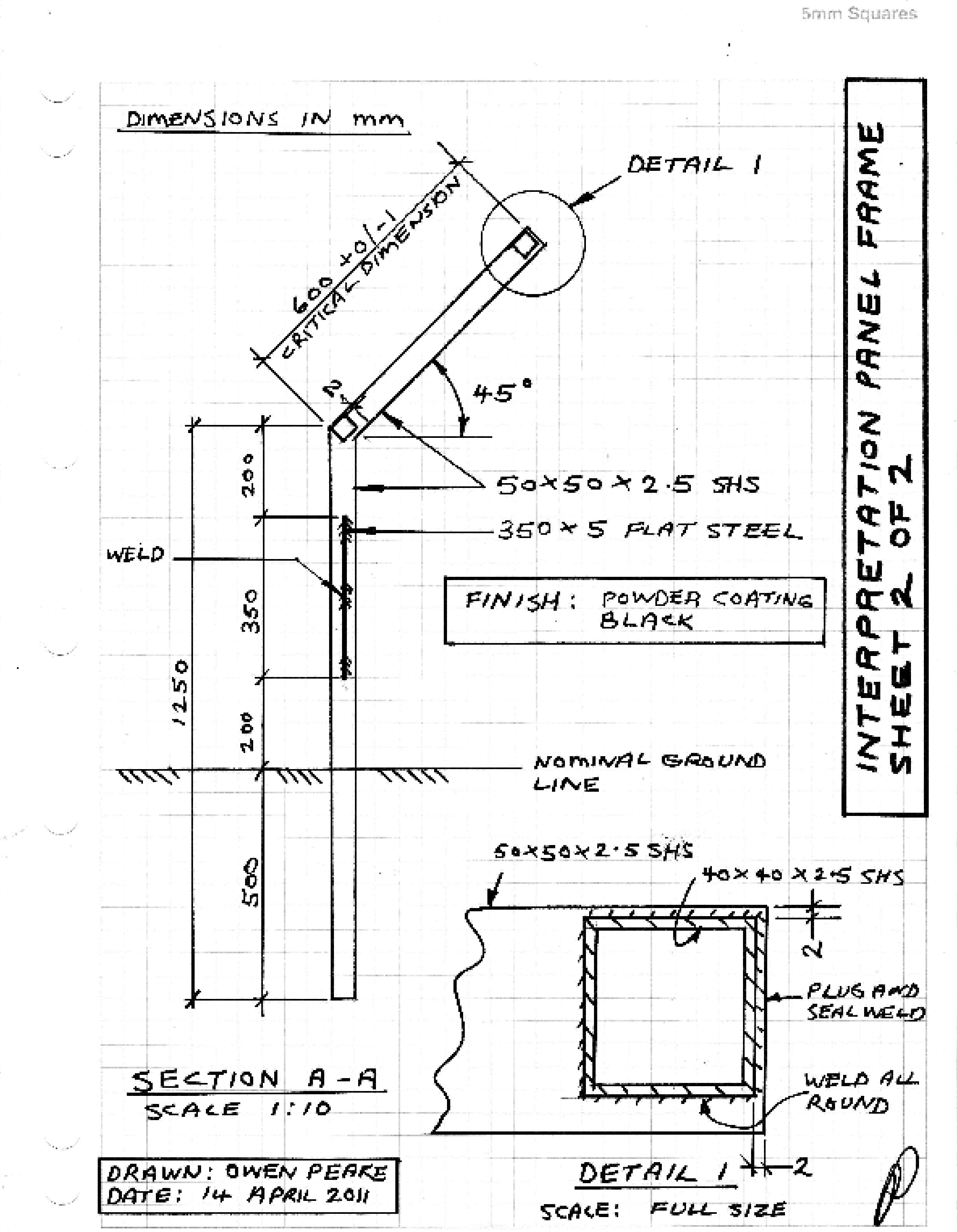
If the thrust curve differed significantly from the initially-assumed profile of the arch, the arch shape would be adjusted to fit the pressure curve, and the calculations repeated using revised segment weights. Generally, only two iterations were needed to achieve satisfactory agreement.

Appendix 9: Interpretation Panel & Mounting Frame Drawings [46]



[46] Note than on the first drawing notes 2 and 3 are incorrect for this site and should be ignored.


5mm Squares
DIMENSIONS IN mm
SCALE: 1:10
1205
A
MOUNTINGS OF
300Ø
MARKER
(TO BE CUSTOM
DRILLED)
NOMINAL GROUND LINE
A
DRAWN: OWEN PEAKE
DATE: 14 APRIL 2011
INTERPRETATION PANEL FRAME
SHEET 1 OF 2


5mm Squares
DIMENSIONS IN mm
DETAIL 1
600 +0/-1
CRITICAL DIMENSION
2
45°
50×50×2·5 SHS
350×5 FLAT STEEL
WELD
FINISH: POWDER COATING BLACK
200
350
1250
200
500
NOMINAL GROUND LINE
INTERPRETATION PANEL FRAME
SHEET 2 OF 2
50×50×2·5 SHS
40×40×2·5 SHS
2
PLUG AND SEAL WELD
WELD ALL ROUND
2
SECTION A-A
SCALE 1:10
DRAWN: OWEN PEAKE
DATE: 14 APRIL 2011
DETAIL 1
SCALE: FULL SIZE

CHANGE CONTROL

VERSION 1	**6 JULY 2012**	**2225 WORDS**	**COMMENCED DRAFTING**
VERSION 2	**8 JULY 2012**	**4718 WORDS**	**FURTHER DRAFTING**
VERSION 3	**10 JULY 2012**	**8106 WORDS**	**FURTHER DRAFTING**
VERSION 4	**10 JULY 2012**	**8235 WORDS**	**CHECK READ**
VERSION 5	**12 JULY 2012**	**8411 WORDS**	**ADDED IMAGES & MAP, CHECK CONTENTS PAGE NUMBERS**
VERSION 6	**15 JULY 2012**	**10466 WORDS**	**ADDED REFERENCE TO CONSERVATIOON MANAGEMENT PLAN**
VERSION 7	**16 JULY 2012**	**11013 WORDS**	**REVISED INTERPRETATION PLAN**
VERSION 8	**17 JULY 2012**	**11103 WORDS**	**REVISED INTERPRETATION PLAN**
VERSION 9	**19 JULY 2012**	**11208 WORDS**	**INCORPORATED COMMENTS BILL JORDAN & MILES PIERCE**
VERSION 10	**19 JULY 2012**	**11077 WORDS**	**INCORPORATED SIGNED NOMINATION LETTER**
VERSION 11	**20 JULY 2012**	**11201 WORDS**	**CHECK READ**
VERSION 12	**27 JULY 2012**	**11204 WORDS**	**ADDED 'CONCRETE' TO SUB TITLE**